FINAL REPORT

AERIAL SPRAY OF FIPRONIL FOR CONTROL OF BOLL WEEVIL

Performing Organization:
Areawide Pest Management Research Unit
Southern Crops Research Laboratory
Southern Plains Area
Agricultural Research Service
U. S. Department of Agriculture
2771 F&B Road
College Station, Texas 77845-4966

Cooperator:
Rhône-Poulenc Ag Company
2609 Schooner
Plano, Texas 75074-2820

Type of Research Agreement: Trust Fund Cooperative Agreement

Research Agreement Number: 58-6202-9-149

Research Agreement Award Date: November 30, 1998

Reporting Period: October 1, 1998 - April 30, 1999

Report of Inventions: None

Report of Sub-awards: None

Document Delivery Services Branch
USDA, National Agricultural Library
Bldg.
Baltimore Blvd.
D 20705-2351

Document Deli
USDA, Nat
Nal Bldg.
10301 Balt
Beltsville,

AERIAL SPRAY OF FIPRONIL FOR CONTROL OF BOLL WEEVIL

USDA Trust Fund Cooperative Agreement No. 58-6202-9-149

FINAL REPORT

To:
Dr. Ann Wiese, Cooperator's Designated Representative
Rhône-Poulenc Ag Company
2609 Schooner
Plano, TX 75074-2820

By:
Ivan W. Kirk, ADODR
USDA, ARS
Areawide Pest Management Research
2771 F&B Road
College Station, TX 77845-4966

Introduction

Aerial electrostatic systems developed by USDA, ARS have potential for improving spray deposition, reducing spray drift, and maintaining or improving efficacy of crop protection materials. Earlier research on electrostatic charging of crop protection materials showed that spray mixes of fipronil accommodated the highest charge-to-mass ratio observed in a study of more than twenty popular cotton insecticides. Charge-to-mass ratio is a critical factor in electrostatic spray application. Rhône-Poulenc Ag Company, the manufacturer of fipronil, is seeking a label for cotton and indicates their expectation to position the material competitively as an alternative to ULV malathion for use in the boll weevil eradication program. The product or trade name for the material under the cotton label is Regent®. These factors led to a cooperative field study that was conducted under the crop destruction EUP for fipronil in the 1998-growing season.

Boll weevil eradication is critical to the competitive posture of cotton. The potential large increases in eradication acreage in 1999 and years following, and the problems that have been observed with continued use of malathion, both point

to the need for effective alternative materials and application methods. Some sources indicate that if all the acreage proposed for 1999 were initiated into the program, that supplies of malathion could be inadequate. Alternative materials are important to continued success and progress in the boll weevil eradication effort.

Electrostatic application is a promising alternative to conventional application methods. Fipronil could provide an alternative to ULV malathion and could contribute to improvements in the boll weevil eradication protocol.

Objective

Determine if the high charge-to-mass ratio of fipronil can be translated into increased spray deposits of fipronil and improved efficacy of the material on over-wintered weevil populations, simulating use in the boll weevil eradication program.

Methods

A sixteen-acre cotton field was located in Burleson County, Texas. The producer was willing to accept payment for crop use for the study and ultimate destruction under Rhône-Poulenc's Experimental Use Permit (Permit 264-EUP-117) for Burleson County. Rhône-Poulenc made arrangements directly with the Manager of Texas A&M University Farm field No. 65 for this study. The relatively small acreage available for the aerial application study and the difficulty of sampling weevil populations in small plots dictated that the experimental design would be composed of one replication of each treatment with heavy sub-sampling in the treated areas. A schematic of the field and sampling layout is shown in Figure 1. Four sampling blocks (A, B, C, and D) were marked with flags in each treatment. Each sampling block had three sub-sample locations (1, 2, and 3) marked with flags on a diagonal in each sampling block. Two rows (cotton was planted in 40-inch rows) in each sampling block each had five pheromone lures attached to the plants to determine if weevils could be attracted preferentially to these rows. Five oil sensitive paper (OSP -- for oil-based spray mixes) or five water sensitive paper (WSP -- for water-based spray mixes) cards were each folded in half and attached to cotton leaves with a straight pin near the top of the canopy at each sub-sample location immediately prior to spray application. The cards collected spray deposit information on both top and bottom of leaves. Six leaves from near the top of the

canopy were collected from each sub-sample location and placed in individual marked plastic bags for fluorometric quantitation of spray deposits. Each sampling block also had a 4"X4" horizontally oriented mylar card located at the top of the canopy for an additional measure of spray deposits. Two leaves from near the top of the crop canopy were collected at sub-sample locations 1 and 2 in each sample block for weevil bioassay analyses on day 0, 3 and 7 after spray application. Individual leaves were placed in petri dishes and ten weevils were placed on the each leaf for mortality assessment. Mortality was determined 24-hours after weevil placement.

Aerial applications of label rate (0.05 lb. a.i./acre) of Regent® 2.5 EC insecticide were made (1) in 1 gpa of water with an electrostatic spray system and (2) in 16 oz/acre of Prime Oil (the first application) and 12 oz/acre of once- refined cottonseed oil (the second and third applications); ULV malathion was also applied at 12 oz/acre. The Regent® in oil and ULV malathion treatments were applied with the nozzle arrangement specified in contracts for the Texas Boll Weevil Eradication Foundation (TBWEF) for the Cessna AgHusky aircraft. Swath widths for all applications were 45 feet. The pilot was instructed to make applications at boom heights of 8-12 feet. This was left to the pilot's judgment, except on June 18 when he was encouraged to fly lower with the electrostatic fipronil treatment. All spray mixes contained 1.2 oz/acre methanol and 5 g/acre caracid brilliant flavine FFS dye as fluorescent tracer for quantitation of spray deposits. Spray deposits were measured with OSP and WSP and with fluorometric tracer deposits on cotton canopy leaves. Efficacy measurements were made with laboratory-reared weevil placements on field-treated leaves. KISS and tractor samplers were used to monitor over-wintered weevil populations. Three over-wintered weevil aerial applications of the three treatments plus untreated check were made, May 29, June 10-11, and June 18, 1998. Weevil populations indicated by punctured square counts never reached economic levels so the planned seasonal weevil control applications were not made.

WSP and OSP were analyzed with computerized image analysis for deposited spray droplet size, droplet density, and percent area covered by spray deposits. Spray deposits on leaves and mylar plates were washed from surfaces in methanol and effluents quantitated by spectrofluorometry. A Li-Cor LI 3100 area meter was used to determine leaf areas.

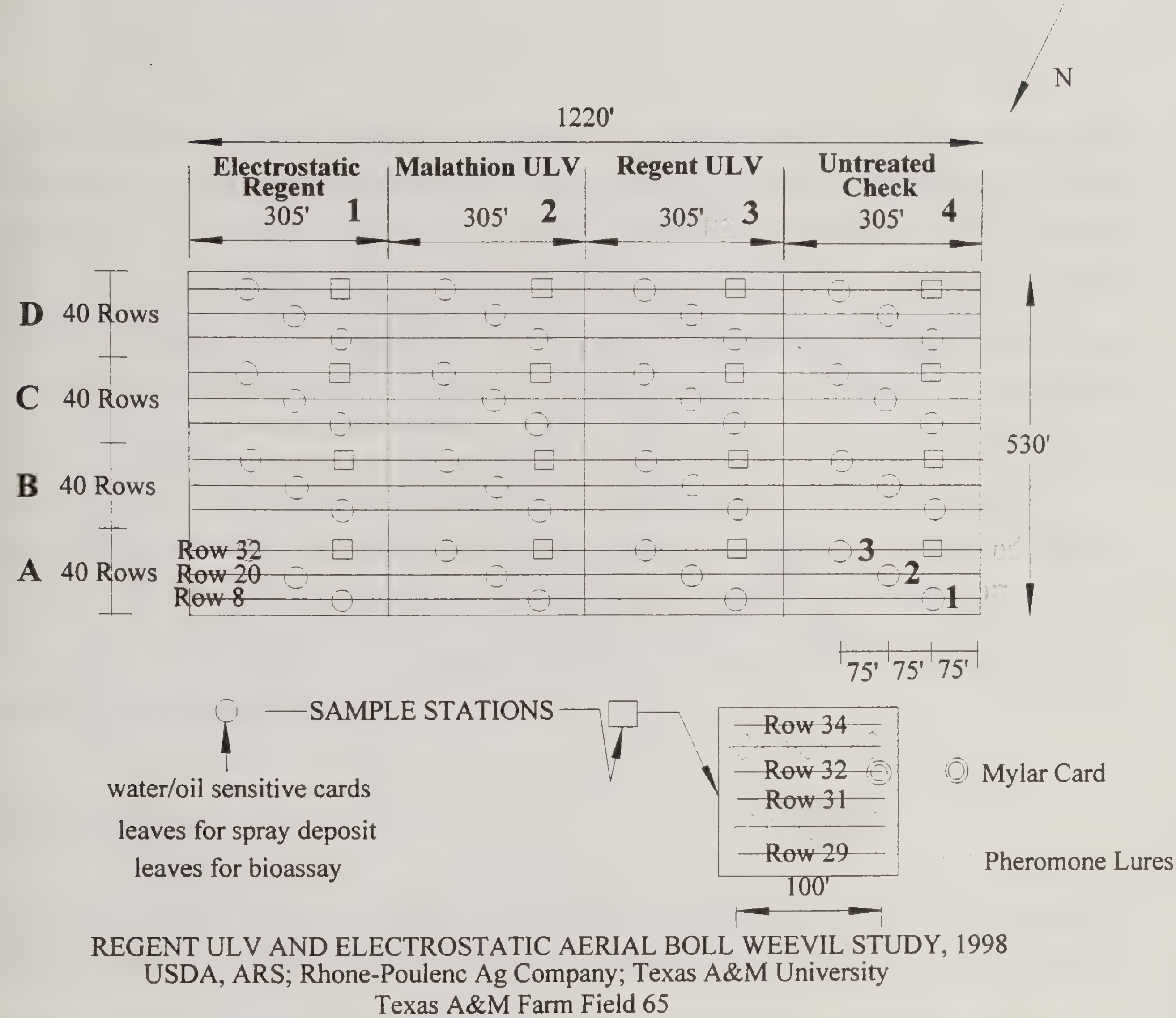

Figure 1. Field and sampling layout for Regent® aerial application study.

Results

Weevil Populations

Weevil populations were not detectable in the treatment blocks before the first scheduled spray date as monitored by 300 row-ft KISS samples. The only insect in significant numbers detected in the first KISS sampling was fleahoppers. The tractor sampler with higher wind velocities and volumes collected only 1 weevil per 3000 row-ft sample. The samplers have collection efficiencies of about 50 percent -- but over-wintered weevil populations were very low at the beginning of the study. We determined to go ahead with the study to get deposition and bioassay data, even though the likelihood of working with native weevil

populations was remote. Weevil populations remained low in the plots throughout the season, even in the untreated check plot. Oviposition punctured square counts averaged 0.1, 0.4, and 0.5 percent across all sampling locations on June 19, June 23, and June 26, respectively. Weevil numbers on these dates averaged across all treatments were 3, 9, and 12 per 300 row-ft KISS samples, respectively, in the pheromone-baited rows compared to 1, 5, and 5, respectively, in non-baited rows. One of the possible reasons for the low weevil numbers in these plots was that they were not irrigated, except for a corner of the check plot that received water from a center-pivot irrigation system in an adjacent field. The plots were surrounded by irrigated cotton that was more attractive to boll weevils. This speculation is supported by oviposition punctured square counts on August 5; punctured square counts in the non-irrigated sections of the field averaged one percent compared to 45 percent in the irrigated corner of the check plot. Plant map data were collected on August 5; as expected there were no treatment differences. The bolls were 75 percent open at that time.

Spray Deposits

Use of WSP and OSP in conjunction with fluorometric dye deposits on leaf and artificial sample surfaces permit multiple parameter assessments of spray deposits.

OSP and WSP Card analyses give measures of spray deposition parameters. These parameters computed from 1060 cards are shown in Table 1. The Treatment X Surface interaction was highly significant for all parameters except D_{min}; Treatment effect was highly significant for D_{min}. There are major differences in the Treatment applications that must be considered in evaluating these data: the electrostatic fipronil treatment was water-based and sampled with WSP — the other two treatments were oil-based and sampled with OSP; the electrostatic fipronil treatment was applied at 1 gpa — ULV malathion was applied and 12 oz/acre and the fipronil in oil treatment was applied at either 12 or 16 oz/acre. However, these differences do not prevent reasonable comparisons or assessments to be made. It is apparent from these data that the two oil-based treatments did not express similar atomization and deposition parameters. Droplet size was smaller and deposit volume was less for fipronil in oil than for ULV malathion.

Table 1. Deposited spray parameters on top and bottom leaf surfaces as computed from stains on WSP and OSP attached to cotton leaves at the top of the crop canopy.

Treatment	Electrostatic Fipronil		ULV Malathion		Fipronil in Oil	
Surface	Top	Bottom	Top	Bottom	Top	Bottom
Parameter						
$D_{V0.5}$	135	80	109	38	55	30
Drops/cm^2	33	20	26	31	27	27
%Coverage	1.20	0.55	0.72	0.13	0.15	0.07
Vol., nL/cm^2	38.6	15.2	7.8	1.0	1.3	0.5
D_{min}	6.9	7.5	3.1	2.3	1.9	1.7
D_{10}	74	47	35	16	13	9
D_{max}	188	110	145	53	77	43
%Vol.<100μm	26	56	43	89	78	90
%Vol.<200μm	78	85	87	99	96	98

$D_{V0.5}$ = volume median diameter, D_{min} = minimum droplet diameter, D_{10} = mean droplet diameter, Dmax = maximum droplet diameter

Cotton Leaves sampled randomly from treated areas give reasonable quantitative measures of spray deposits. Spray deposits can be quantified by image analysis of stains on WSP and OSP and by fluorometric analysis of leaf wash effluents. Previous experience has shown that fluorometric analysis usually gives a superior quantitation. Fluorometric data from the study are shown in Table 2. Treatment means for both measurements were significantly different. Since the same amount of dye per acre was applied in all sprays, the dye deposit measurements give an indication of the efficiency of delivery of simulated active ingredients to leaf surfaces. More dye was deposited on leaf surfaces with the 12 oz/acre ULV malathion treatment than with the fipronil in 12-16 oz/acre cottonseed oil or the electrostatic fipronil in 1 gpa of water. The high spray deposit with the electrostatic fipronil treatment reflects the higher 1 gpa spray rate as compared to the 12-16-oz/acre spray rate for the other two treatments. The ULV malathion and the fipronil in oil treatments, with similar spray rates applied, indicate that the ULV malathion treatment gave higher active ingredient deposits and spray deposits.

Table 2. Spray deposits on cotton leaves as computed from fluorometric analyses of leaf wash effluents.

Treatment / Parameter	Electrostatic Fipronil	ULV Malathion	Fipronil in Oil
Dye Deposit, ng/cm^2	24.7	36.1	11.8
Spray Deposit, nL/cm^2	18.7	2.6	1.1

There was a significant date by treatment interaction for Spray Deposit, Table 3. The differences in spray deposit for fipronil in oil for the 16 oz/acre spray rate on May 29 compared to 12 oz/acre spray rate on June 10 and June 18 are indicated by trend but the differences are not significant. The major factor contributing to the interaction is the higher deposits from the electrostatic fipronil treatment on June 18 and May 29. These differences may be related to other application conditions or meteorological differences that were not accounted for in the study. A possible reason for the higher spray deposits with the electrostatic fipronil treatment on June 18 was our emphasis for flight close to the canopy. There were instances on this date of the aircraft wheels slapping cotton leaves at the top of the canopy when these applications were made.

Table 3. Spray deposits, nL/cm^2, for three treatments on three application dates.

Treatment / Date	Electrostatic Fipronil	ULV Malathion	Fipronil in Oil
May 29	16.1 b	3.1 d	1.9 de
June 10-11	9.3 c	1.7 de	0.4 e
June 18	30.7 a	2.9 d	1.0 e

Means followed by the same letter or group of letters are not significantly different based on Fisher's Protected LSD at 0.05.

Weather

Weather parameters were monitored during spray applications to account for their influence on spray applications. The applications were made in the morning and the sequence of treatments is apparent from increasing temperature and decreasing relative humidity, Table 4. The sequence of treatments was not randomized within dates to facilitate convenience in handling the sequence of pesticides in the aircraft hopper. There appears to be little information in the weather data that would account for the observed spray deposition differences on the different dates. One possible exception is that higher wind velocities on June 10-11 could have contributed to lower on-target spray deposits.

Table 4. Weather data on three application dates.

Parameter	Temperature, °F	Relative Humidity, %	Wind Velocity, mph	Stability Ratio, $°C \cdot s^2/m^2$ *
Date				
May 29				
Elec. Regent	92	56	5.0	3.34
ULV malathion	85	72	5.8	1.56
Regent in oil	89	64	5.4	2.12
June 10-11				
Elec. Regent	93	54	13.0	-0.20
ULV malathion	82	88	9.0	0.02
Regent in oil	85	80	11.8	-0.07
June 18				
Elec. Regent	92	47	5.8	0.92
ULV malathion	85	61	7.3	N/A
Regent in oil	87	56	7.2	0.68

* $SR = 10^5(T_{10} - T_{2.5})/U_5^2$ (ASAE S387.2, 1991)

Weevil Mortality -- Laboratory Bioassay

Weevil mortalities in laboratory bioassays were highly variable but the Electrostatic fipronil and ULV malathion treatments both gave above 95 percent weevil mortality on the day of spray application, Table 5. Mortality from the fipronil in oil treatment was lower than for the other two treatments on all of the bioassay days. Electrostatic applications of fipronil gave significantly higher weevil mortalities than the ULV malathion treatment on day-3 after spraying. Effectiveness of the three treatments had dissipated by day 7 after treatment application.

Table 5. Percent boll weevil mortality in laboratory bioassays.

Treatment	Electrostatic Fipronil	ULV Malathion	Fipronil in Oil
DAT			
0	97	95	77
3	50	33	18
7	2	2	1

Discussion

It is apparent from the data analyses that a problem occurred with deposition of the treatment with fipronil in cottonseed oil. There was considerable discussion among project leaders on the appropriate vegetable oil to use as the diluent for this treatment. We had previous experience with Prime Oil and used it for the first application date. However a decision was made to use once-refined cottonseed oil for the last two applications, based on good results reported from studies in Mississippi with fipronil in once-refined cottonseed oil. It is logical to think, based on perusal of all of these data, that flow rate of the fipronil in cottonseed oil was lower than ULV malathion. However, a SATLOC Flow Control was used to control flow rate during application. It is not expected that viscosity differences between the two oil-based spray mixes would make a significant difference in flow

rate monitored by the flow controller. This matter warrants further study if general recommendations are made for vegetable oil as a ULV diluent for fipronil.

It would be desirable to conduct a large-scale irrigated field study with treatment plots large enough for adequate assessments of treatment effects on native boll weevil populations. Information for this study would be valuable in designing a study of the effects of electrostatic fipronil applications on boll weevil populations.

ANNUAL RESEARCH PROGRESS REPORT
Report of Progress (AD-421)

Accession: 0401376 Year: 1998 Project Number: 6202-22000-012-16 R
Mode Code: 6202-40-05 STP Codes: 2.2.4.1 100%
National Program(s):

Title: EFFICACY OF AERIAL ELECTROSTATIC SPRAY CHARGING TECHNOLOGY FOR BOLL WEEVIL CONTROL ON COTTON

Period Covered: From: 01/98 To: 12/98

Would you like to terminate this Project? N

Progress and Outcomes:

Question 1: What major problem or issue is being resolved and how are you resolving it?

Aerial electrostatic systems developed under the parent CRIS have potential for improving spray deposition, reducing spray drift, and maintaining or improving efficacy of crop protection materials. Earlier research under the parent CRIS showed that spray mixes of fipronil would accept a high charge-to-mass ratio, which is a critical factor in electrostatic spray application. The manufacturer of fipronil is seeking a label for cotton and indicates their expectation to posture the material competitively as an alternative to ULV malathion in the boll weevil eradication program. These potentials led to a cooperative field study that was conducted under the crop destruction EUP for fipronil in 1998.

Question 2: How serious is the problem? Why does it matter?

Boll weevil eradication is critical to the competitive posture of cotton. The potential large increases in eradication acreage in 1999 and years following, and the problems that have been observed with continued use of malathion, both point to the need for effective alternative materials and application methods. Some sources indicate that if all the acreage proposed for 1999 were initiated into the program, that supplies of malathion could be inadequate. Alternative materials are important to continued success and progress in the boll weevil eradication effort.

Question 3: How does it relate to the National Program(s) and National Program Component(s) to which it has been assigned?

Crop production and protection objectives encompass advances in improved materials and systems. Electrostatic application is a promising alternative to conventional application methods. Fipronil could provide an alternative to ULV malathion and could contribute to improvements in the boll weevil eradication protocol.

Question 4: What was your most significant accomplishment this past year?

Aerial electrostatic applications of fipronil showed higher weevil mortality and extended effectiveness when compared to ULV malathion in laboratory bioassays.

Question 5: Describe your major accomplishments over the life of the project, including their predicted or actual impact.

Aerial electrostatic applications of fipronil showed higher weevil mortality and extended effectiveness when compared to ULV malathion in laboratory bioassays. Potential impact projected from field application studies and laboratory bioassays point to improved performance of electrostatic fipronil compared to ULV malathion. This could mean longer spray intervals and reduced costs associated with the boll weevil eradication program.

Question 6: What do you expect to accomplish during the next year?

Provided EPA completes registration of fipronil for use on cotton before the 1999 cotton production season, a more extensive field study of electrostatic fipronil will be conducted. Plots will be large enough to adequately assess boll weevil mortality comparisons with ULV malathion.

Question 7: What technologies have been transferred to and to whom? When is the technology likely to become available to the end user (industry, farmer, other scientists)? What constraints, if known to the adoption and durability of the technology?

A patent for the electrostatic spray system has been licensed to Spectrum Electrostatic Technologies. They currently have a production prototype under continuous use and evaluation in Panama. The success of the prototype system

and registration of fipronil are critical to the technology becoming available for use in the boll weevil eradication program. Registration of fipronil for use on cotton is expected from EPA in early to mid 1999. The outcome of production efficacy trials with the electrostatic system will dictate the availability of systems produced for commercial use.

Question 8: List your most important popular publications and presentations, and articles written about your work (up to three total — NOTE: this does not replace your reviewed publications which are listed below)

Unpublished progress report for internal use by commercial cooperators. September 1998.

Presentation of results of the current study to ASAE PM-41/2. December 1998.

Publications

None